



Validation of the MODIS active fire product by coincident ASTER observations in Southern Africa

J. Morisette, L. Giglio (NASA Goddard Space Flight Center), I. Csizsar and C.O. Justice (Department of Geography, University of Maryland)



BACKGROUND

- GOFC/GOLD-Fire**
 - “Determine product accuracy – operational network of fire validation sites and protocols established providing accuracy assessment for operational products and test bed for new or enhanced products – leading to standard products of known accuracy”
 - “Increase user awareness – increased understanding of the utility of satellite fire products for global change research, resource management and policy (UN, Regional, National, Local)”
- CEOS WGCY LPV subgroup**
 - “increase the quality and economy of global satellite product validation *via* developing and promoting international standards and protocols for field sampling, scaling, error budgeting, data exchange and product evaluation”
 - “advocate mission-long validation programs for current and future earth observing satellites”
- MODLAND validation**
 - “comparison of data and products from other spaceborne sensors”

METHOD

ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer

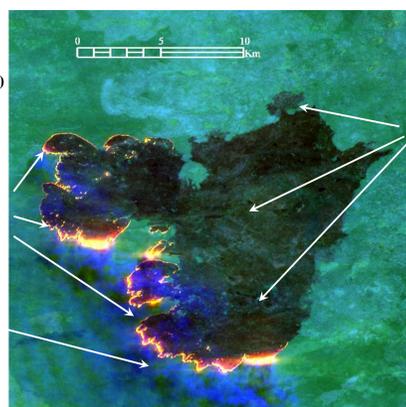
- On board Terra (*not* on board Aqua)

	VNIR	SWIR	TIR
Spectral	1: 0.52 - 0.60	4: 1.600 - 1.700	10: 8.125 - 8.475
	2: 0.63 - 0.69	5: 2.145 - 2.185	11: 8.475 - 8.825
range	3: 0.76 - 0.86	6: 2.185 - 2.225	12: 8.925 - 9.275
	3B*: 0.76 - 0.86	7: 2.235 - 2.285	13: 10.25 - 10.95
		8: 2.295 - 2.365	14: 10.95 - 11.65
(μm)		9: 2.360 - 2.430	
Ground res. (m)	15	30	60
Swath width (km)	60	60	60
Quantization (bits)	8	8	12

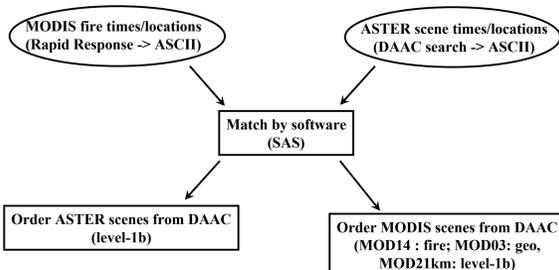
*Backward looking; all other sensors nadir looking

Fire observations with ASTER

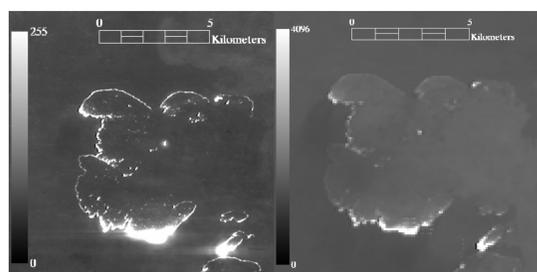
Aug 17 2001
09:08 UTC
18.8S 19.9 E
(NE Namibia)



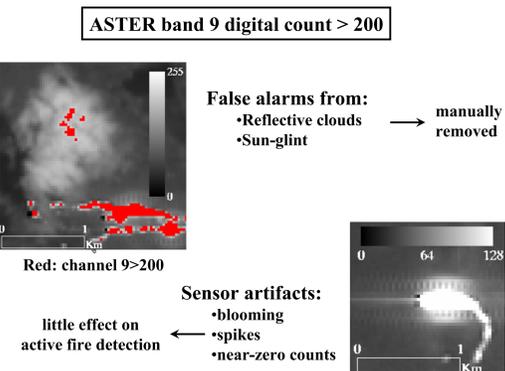
ASTER-MODIS fire coincidence search: semi-automated procedure



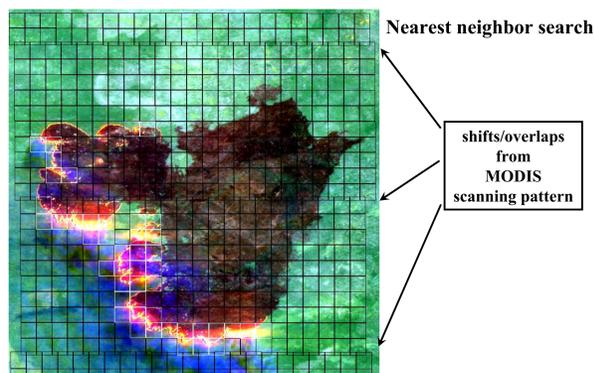
ASTER band selection



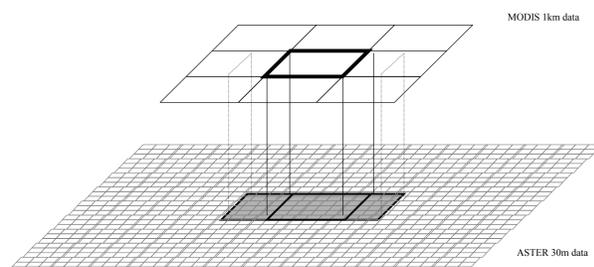
ASTER fire detection “algorithm”



Collocating ASTER and MODIS data



ASTER binary masks within MODIS footprints



MODIS active fire products considered

- Level 2 fire products for 5-minute orbital segments
 - Version 3: currently operational, persistent false detections caused by absolute thresholds
 - Version 4: new algorithm, relies heavily on contextual tests – by the end of 2002 the entire data record will be reprocessed

Statistical summaries within MODIS footprints

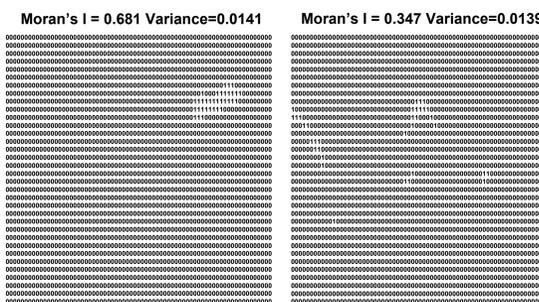
Fractional area: number of ASTER fire pixels

Fire heterogeneity: Moran's I

$$\text{Moran's } I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \mu)(y_j - \mu)}{\sum_{i=1}^n (y_i - \mu)^2 \left(\sum_{j \neq i} w_{ij} \right)}$$

n : number of ASTER pixels covered by a MODIS pixel
 w_{ij} : 1 for the eight adjacent pixels and 0 for all others
 y_i : value of the ASTER fire pixel (either 0 or 1) for pixel i
 μ : mean of ASTER fire map for the area represented by the MODIS pixel

Binary ASTER fire masks



Total number of ASTER fire pixels = 34

Statistical method for comparison

MODIS “fire/no fire” ↔ statistical summaries from binary ASTER fire mask

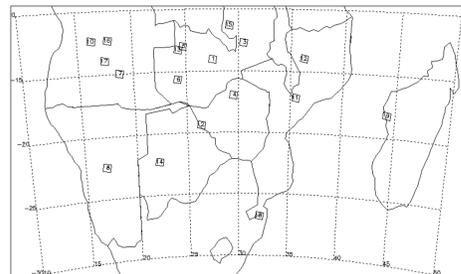
Fixed effect models (within-scene variability only) Random effect models (include between-scene variability also)

Model 1 $\pi(x_i) = \frac{e^{\beta_0 + \beta_1 x_i}}{1 + e^{\beta_0 + \beta_1 x_i}}$ $\pi(x_{ij}) = \frac{e^{(\beta_0 + b_{0j}) + (\beta_1 + b_{1j}) x_{ij}}}{1 + e^{(\beta_0 + b_{0j}) + (\beta_1 + b_{1j}) x_{ij}}}$

Model 2 $\pi(x_i, m_i) = \frac{e^{\beta_0 + \beta_1 x_i + \beta_2 m_i}}{1 + e^{\beta_0 + \beta_1 x_i + \beta_2 m_i}}$ $\pi(x_{ij}, m_{ij}) = \frac{e^{(\beta_0 + b_{0j}) + (\beta_1 + b_{1j}) x_{ij} + (\beta_2 + b_{2j}) m_{ij}}}{1 + e^{(\beta_0 + b_{0j}) + (\beta_1 + b_{1j}) x_{ij} + (\beta_2 + b_{2j}) m_{ij}}}$

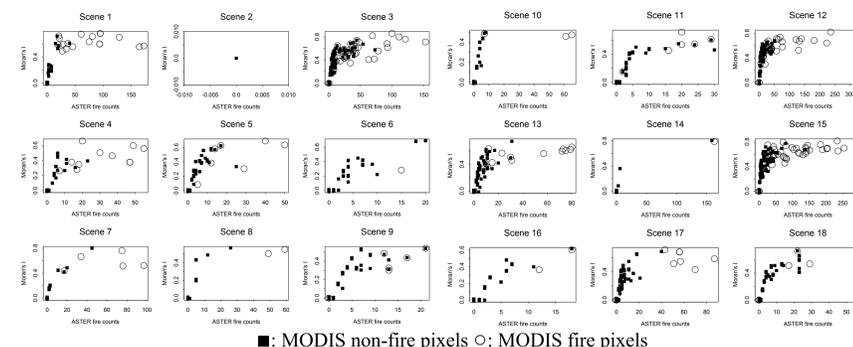
i denotes MODIS pixel; j denotes ASTER scene
 x : count of ASTER fire pixels within MODIS pixel
 m : Moran's I within MODIS pixel
 π : probability that MODIS pixel is flagged as “fire”
 $\beta_0, \beta_1, \beta_2$: fixed effects parameters estimated from the data population
 b_{0j}, b_{1j}, b_{2j} : random effects parameters associated with experimental units drawn at random

DATA

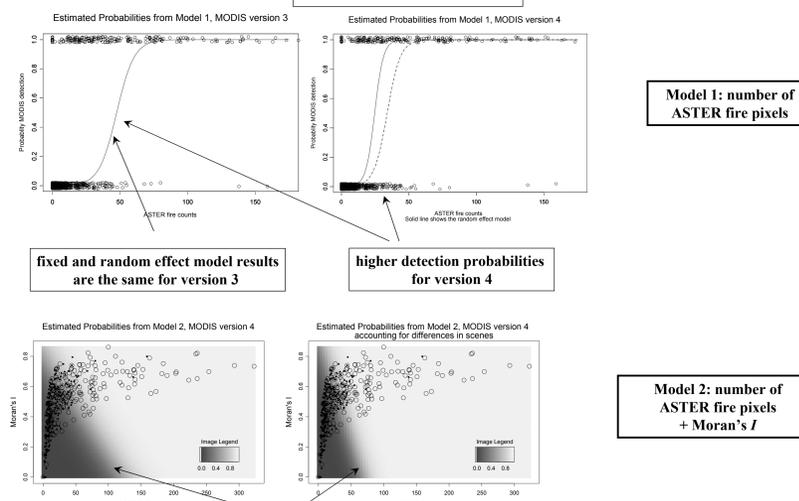


Scene	ASTER filename	Date	Lat	Lon	Coincident MODIS granule ID
1	pg-PR1B0000-2001081702_091_001	5-Aug	-14.04	27.53	MOD14.A2001217.0840.svv.v*.hdf
2	pg-PR1B0000-2001081702_095_001	5-Aug	-19.39	26.36	MOD14.A2001217.0840.svv.v*.hdf
3	pg-PR1B0000-2001091402_112_001	1-Sep	-12.69	30.48	MOD14.A2001244.0820.svv.v*.hdf
4	pg-PR1B0000-2001091402_031_001	1-Sep	-16.96	29.52	MOD14.A2001244.0820.svv.v*.hdf
5	pg-PR1B0000-2001091602_042_001	4-Sep	-12.98	24.73	MOD14.A2001247.0850.svv.v*.hdf
6	pg-PR1B0000-2001091602_045_001	4-Sep	-15.65	24.15	MOD14.A2001247.0850.svv.v*.hdf
7	pg-PR1B0000-2001092202_069_001	9-Sep	-14.98	18.69	MOD14.A2001252.0910.svv.v*.hdf
8	pg-PR1B0000-2001092202_001_001	9-Sep	-22.46	16.98	MOD14.A2001252.0910.svv.v*.hdf
9	pg-PR1B0000-2001100702_081_001	18-Sep	-18.19	44.26	MOD14.A2001261.0725.svv.v*.hdf
10	pg-PR1B0000-2001101102_017_001	23-Sep	-12.33	16.31	MOD14.A2001266.0920.svv.v*.hdf
11	pg-PR1B0000-2001101302_111_001	28-Sep	-17.17	35.56	MOD14.A2001271.0800.svv.v*.hdf
12	pg-PR1B0000-2001101302_275_001	28-Sep	-13.96	36.26	MOD14.A2001271.0800.svv.v*.hdf
13	pg-PR1B0000-2001101502_039_001	29-Sep	-13.24	24.27	MOD14.A2001272.0845.svv.v*.hdf
14	pg-PR1B0000-2001101502_050_001	29-Sep	-22.31	22.15	MOD14.A2001272.0845.svv.v*.hdf
15	pg-PR1B0000-2001101603_130_001	1-Oct	-11.29	29.14	MOD14.A2001274.0830.svv.v*.hdf
16	pg-PR1B0000-2001101603_155_001	2-Oct	-12.32	17.78	MOD14.A2001275.0915.svv.v*.hdf
17	pg-PR1B0000-2001101603_017_001	2-Oct	-13.92	17.43	MOD14.A2001275.0915.svv.v*.hdf
18	pg-PR1B0000-2001102002_118_001	5-Oct	-26.83	32.13	MOD14.A2001278.0810.svv.v*.hdf

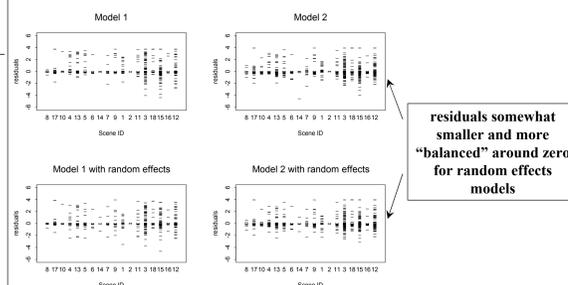
Characteristics of ASTER scenes



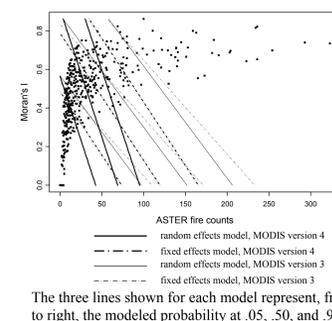
RESULTS



Model residuals

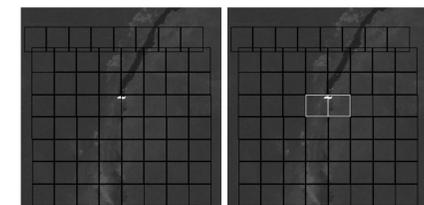


Model summary

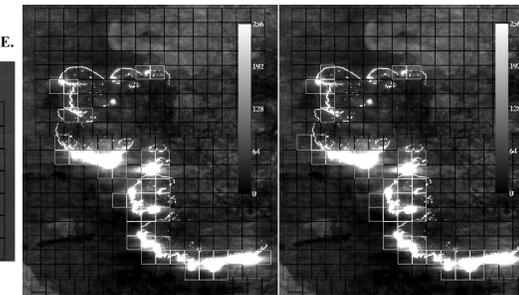


Effects of MODIS algorithm change

“Dambo” fire in Western Zambia, August 12 2001, 16.6S 24.4E.



Fire front in NE Namibia, August 17 2001, 18.8S 19.9E.



SUMMARY

- detection probabilities from the logistic regression models presented characterize well omission errors; for commission errors other variables may be needed
- there is some sensitivity to model formulation and data sampling
- MODIS version 3 -> version 4 algorithm change had a positive effect on fire product accuracy
- “false alarms” next to valid fire pixels remain
- in Southern Africa, a large number of small fires remain undetected